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Dept. of Enviro. Quality
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**STATISTICAL EVALUATION OF
MARCH 2008 AND JUNE 2008
GROUNDWATER QUALITY DATA**

HELENA, MONTANA

Prepared For:

**CITY OF HELENA
HELENA, MONTANA**



Hydrometrics, Inc.
consulting scientists and engineers

SEPTEMBER 2008



Hydrometrics, Inc.
consulting scientists and engineers

3020 Bozeman Avenue
Helena, MT 59601
(406) 443-4150
Fax: (406) 443-4155
www.hydrometrics.com

September 30, 2008

Ms. Mary Louise Hendrickson
Environmental Science Specialist
Montana Department of Environmental Quality
Solid Waste Regulatory Program
P.O. Box 200901
Helena, MT 59620-0901

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OCT 01 2008

Dept. of Enviro. Quality
Waste & Underground
Tank Management Bureau

RE: Statistical Evaluation of March 2008 and June 2008 Groundwater Quality Data

Dear Mary Louise,

On behalf of the City of Helena, Hydrometrics completed a statistical evaluation of groundwater quality data for samples collected at the City's municipal landfill in March 2008 and June 2008. After receiving approval from Ben Sautter of the City of Helena, I am forwarding a copy of the report "Statistical Evaluation of March 2008 and June 2008 Groundwater Quality Data" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: John Rundquist, City of Helena, without Enclosure
Ben Sautter, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

**STATISTICAL EVALUATION OF
MARCH 2008 AND JUNE 2008
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

Prepared for:

Mr. John Rundquist
CITY OF HELENA
City/County Building
316 North Park Avenue
Helena, MT 59623

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

September 2008

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**STATISTICAL EVALUATION OF
MARCH 2008 AND JUNE 2008
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the June 2008 monitoring event, and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2006). In addition, results for a set of groundwater samples collected in March 2008 under the same sampling protocol are discussed. The March 2008 samples were collected primarily to monitor the effectiveness of the groundwater extraction system that became operational in June 2000.

ARM 17.50.708(12) and ARM 17.50.708(13) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, control charts, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;
- Concentrations of PCE are decreasing over time in well EPA-1, the well that has historically shown the highest concentrations; and
- Elevated nitrate plus nitrite as N (nitrate) concentrations exist both upgradient and downgradient of the landfill at similar levels.

These findings are further evaluated in this June 2008 statistical report through an assessment of current concentrations (Table 3-1), a comparison of summary statistics (Tables 3-2 and 3-3), and examination of temporal trends (Figures 3-1 and 3-2).

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill has been capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill are typically included in the semiannual monitoring program and are characterized as follows:

- Background wells: HL-06-1 (replacing 83-6), HL-94-1, HL-94-2, MPC-5;
- Downgradient wells: HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2,
EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

The locations of these wells are shown in Figure 2-2. Due to damaged sustained by well 83-6, this well was abandoned in October 2006 and a new well, HL-06-1, was drilled to replace this important upgradient well. For historical comparisons in this report, results from HL-06-1 and 83-6 will be included.



NO SCALE

CITY OF HELENA LANDFILL
STATISTICAL EVALUATION OF
MARCH 2008 AND JUNE 2008
GROUNDWATER QUALITY DATA

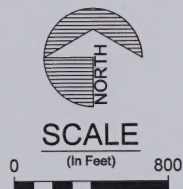
VICINITY MAP

FIGURE

2-1



SITE CODE	DTWL	MPE	SWL
Jun-08			
HL-06-1	19.06	3993.62	3974.56
82-3	69.24	3973.51	3904.27
EPA-1	48.00	3981.08	3933.08
EPA-4	76.82	3973.83	3897.01
HL-90-1	58.39	3942.48	3884.09
HL-90-2	50.71	3950.96	3900.25
HL-90-3	65.52	3958.29	3892.77
HL-94-1R	59.30	3994.04	3934.74
HL-94-2	25.76	3966.19	3940.43
HL-94-3	36.64	3967.38	3930.74
HL-99-1	75.30	3943.15	3867.85
HL-99-2	89.09	3945.75	3856.66
HL-99-3	75.50	3948.05	3872.55
INF. GALLE	10.58	3918.89	3908.31
I-1	67.18	3899.59	3832.41
MPC-1	23.44	3946.08	3922.64
MPC-2	17.43	3936.09	3918.66
MPC-5	57.30	3990.14	3932.84



LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INF. GALLE INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

**STUDY AREA AND JUNE 2008
POTENTIOMETRIC SURFACE**

FIGURE

2-2



SITE CODE	DTWL	MPE	SWL
Jun-08			
HL-06-1	19.06	3993.62	3974.56
82-3	69.24	3973.51	3904.27
EPA-1	48.00	3981.08	3933.08
EPA-4	76.82	3973.83	3897.01
HL-90-1	58.39	3942.48	3884.09
HL-90-2	50.71	3950.96	3900.25
HL-90-3	65.52	3958.29	3892.77
HL-94-1R	59.30	3994.04	3934.74
HL-94-2	25.76	3966.19	3940.43
HL-94-3	36.64	3967.38	3930.74
HL-99-1	75.30	3943.15	3867.85
HL-99-2	89.09	3945.75	3856.66
HL-99-3	75.50	3948.05	3872.55
INF. GALLE	10.58	3918.89	3908.31
I-1	67.18	3899.59	3832.41
MPC-1	23.44	3946.08	3922.64
MPC-2	17.43	3936.09	3918.66
MPC-5	57.30	3990.14	3932.84



LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 3900 — POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- ↘ STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
STATISTICAL EVALUATION OF
MARCH 2008 AND JUNE 2008
GROUNDWATER QUALITY DATA

STUDY AREA AND JUNE 2008
POTENTIOMETRIC SURFACE

FIGURE
2-2

2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in June 2008 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. The potentiometric surface in the area of well HL-94-3 suggests that groundwater flows to the northwest (Figure 2-2); thus, well HL-94-3 is not considered to be upgradient or downgradient of the landfill. Well HL-94-3 has, therefore, been designated as a “cross-gradient” well for statistical comparison purposes, and the sampling results for monitoring well HL-94-3 are evaluated separately from other monitoring wells.

Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the June 2008 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report “Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill” (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0241 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.7122 ft/day.

2.4 SUMMARY OF MARCH 2008 QUARTERLY DATA

Monitoring wells HL-99-1, HL-99-2 and HL-99-3 were sampled in March 2008 for purposes of evaluating the progress of the new groundwater extraction system (Hydrometrics, 1999b), which was started in June of 2000. In addition, domestic well #5, located downgradient from the landfill (Figure 2-2), was sampled during the March 2008 monitoring event to further evaluate VOC concentrations in residential wells north of Custer Avenue. All wells were sampled for volatile organics, semi-volatile organics, and halogenated organics.

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
EPA-1	2.8	0.0328	0.367
HL-90-1	20	0.0798	6.39
HL-90-2	5.6	0.0334	0.749
HL-90-3	0.03	0.0618	0.00741
HL-94-1R	2.8	0.00291	0.0326
HL-94-2	0.28	0.0595	0.0666
HL-94-3	2.8	0.0156	0.174
HL-99-1	10	0.0600	2.40
HL-99-2	20	0.0645	5.16
HL-99-3	20	0.0623	4.98
HL-06-1	0.03	0.0404	0.00485
I-1	20	0.0231	1.85
Infiltration Gallery	5.6	0.0258	0.578
MPC-1	2.8	0.0218	0.244
MPC-2	2.8	0.0288	0.322
MPC-5	2.8	0.0274	0.307

The water samples collected for the City of Helena Landfill in March 2008 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, 2006). No samples were rejected or qualified based on results of the data review. The validated data was included in the data validation report for that sampling event (Hydrometrics, 2008a). Overall, the City of Helena Landfill data for March 2008 were deemed acceptable for the purposes of the project as outlined in the work plan.

2.5 SUMMARY OF JUNE 2008 SEMIANNUAL DATA

All fourteen monitoring wells around the landfill, eight domestic wells, and the infiltration gallery well were included in the June 2008 sampling event. In addition, static water levels

(SWL) were obtained from two monitoring wells and two irrigation wells. The June 2008 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells 82-3 (SWL only), HL-06-1, EPA-1, EPA-4 (SWL only), HL-90-1, HL-90-2, HL-90-3, HL-94-1, HL-94-2, HL-94-3, HL-99-1, HL-99-2, HL-99-3, MPC-1, MPC-2, MPC-5;
- Irrigation wells I-1 (SWL only) and I-4;
- Domestic wells 5, 16, 40, 48, 52, 57, 62, 90; and
- The infiltration gallery.

The owner of well 90 could not be reached despite repeated attempts and thus this well could not be sampled during the June 2008 monitoring event. Analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for the monitoring wells and volatile organics, semi-volatile organics, and halogenated organics for all remaining wells as specified in the approved sampling and analysis plan (Hydrometrics, 2006).

The water samples collected for the City of Helena Landfill in June 2008 have been validated by the Hydrometrics' Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2006). Lab and field quality control procedures were appropriate and no samples were rejected or qualified based on results of the data review. The validated data was included in the data validation report for that sampling event (Hydrometrics, 2008b). Overall, the City of Helena Landfill data for June 2008 were deemed acceptable for the purposes of the project as outlined in the work plan.

3. STATISTICAL DATA EVALUATION AND COMPARISON

Two types of data evaluations were conducted using the June 2008 sample results for 13 of the 14 monitoring wells around the landfill (cross-gradient well HL-94-3 is evaluated separately in Section 4). These are:

1. Comparisons of applicable water quality criteria and upgradient (also called "background") water quality with summary statistics of downgradient concentrations for June 2008 and all samples to date; and
2. Temporal concentration plots.

The first evaluation, (comparison of upgradient and downgradient water quality relative to water quality criteria) includes all those parameters for which results were reported above the detection limit in any of the 14 monitoring wells for the June 2008 sampling event.

The second evaluation, Temporal Concentration Trends, was performed for PCE and nitrate, the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells which have historically shown PCE results above the detection limit of 0.001 mg/L and nitrate results above the MCL of 10 mg/L or with potentially increasing trends were evaluated.

Because only downgradient monitoring wells were sampled during the March 2008 quarterly sampling event, downgradient versus upgradient comparisons were not completed for this data. However, this data is included in the June 2008 evaluation of all samples to date and the temporal concentration plots. The results of the quarterly sampling are further evaluated in Section 3.3 of this report.

3.1 DOWNGRAIDENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the June 2008 data and summary statistics in Tables 3-1, 3-2, and 3-3:

- (a) For the June 2008 sampling event (Tables 3-1 and 3-2), the following parameters were detected only in background (also called upgradient) wells: arsenic, cobalt, copper, vanadium, 1,1,1-trichloroethane, and chemical oxygen demand. Parameters detected in only downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), and trichloroethene (TCE).
- (b) Parameters historically detected only in downgradient wells (Table 3-3) include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE. Parameters historically detected in only upgradient wells include copper and vanadium.
- (c) Nitrate, arsenic, iron, cyanide, and PCE were reported at concentrations exceeding MCL criteria in the June 2008 sampling event (Tables 3-1 and 3-2). The MCL for nitrate was exceeded in one downgradient well (MPC-1) and one upgradient well (MPC-5); the MCLs for arsenic and cyanide were exceeded in a single upgradient well (MPC-5); the MCL for PCE was exceeded in two downgradient wells (MPC-1 and HL-99-3); the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).
- (d) Historically, nitrate, arsenic, iron, PCE, TCE and cyanide have been reported at concentrations exceeding MCL criteria (Table 3-3). The MCLs for PCE and TCE have been exceeded in only downgradient wells; arsenic, iron, and nitrate have exceeded their MCLs in both upgradient and downgradient wells and the MCL for cyanide has been exceeded in only upgradient wells. The June 2008 data is generally consistent with these trends.

**TABLE 3-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS
FOR THE JUNE 2008 MONITORING EVENT**

Parameter	Downgradient Wells									Upgradient Wells				Cross-gradient Well	MCL ⁽¹⁾
	HL-90-1	HL-90-2	HL-90-3	MPC-1	MPC-2	EPA-1	HL-99-1	HL-99-2	HL-99-3	HL-06-1	MPC-5	HL-94-1	HL-94-2	HL-94-3	
Field pH (s.u.)	8.12	7.76	8.18	8.07	6.8	7.66	6.93	7.09	7.23	7.7	8.08	8.14	7.6	8.03	NA
Field Specific Conductance (µmhos/cm)	929	731	1043	884	843	1356	1089	808	960	1053	4418	981	923	805	NA
Sulfate	NM	51	170	190	NM	130	170	120	160	86	1000	98	60	160	NA
Chloride	NM	33	55	61	NM	92	71	43	50	26	31	23	65	79	NA
Nitrate+Nitrite as N	NM	0.73	9.8	11.8	NM	3.68	9.3	6.75	8.9	0.81	18.8	3.75	3.81	11.1	10
Arsenic (Dissolved)	NM	<0.005	<0.005	<0.005	NM	<0.005	<0.005	<0.005	<0.005	<0.005	0.037	<0.005	0.008	<0.005	0.020
Cobalt (Dissolved)	NM	<0.01	<0.01	<0.01	NM	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	NA
Copper (Dissolved)	NM	<0.01	<0.01	<0.01	NM	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	1.3
Iron (Dissolved)	NM	<0.03	<0.03	<0.03	NM	0.03	<0.03	<0.03	<0.03	<0.03	2.62	<0.03	<0.03	0.07	0.3 ⁽²⁾
Nickel (Dissolved)	NM	<0.01	<0.01	<0.01	NM	0.02	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.100
Vanadium (Dissolved)	NM	<0.1	<0.1	<0.1	NM	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	NA
1,1,1-Trichloroethane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0042	<0.001	<0.001	<0.001	<0.001	0.2
1,1-Dichloroethane	0.0012	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.0012	0.0026	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Chloroform	0.0012	<0.001	0.0095	0.0018	<0.001	<0.001	0.0033	0.0016	0.0023	<0.001	<0.001	0.0063	<0.001	0.013	0.06
Cis-1,2-Dichloroethene	<0.001	<0.001	<0.001	0.0012	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.07
Dichlorodifluoromethane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0017	<0.001	<0.001	<0.001	<0.001	<0.001	1.0
Tetrachloroethene (PCE)	0.0039	<0.001	<0.001	0.0062	<0.001	0.0015	0.0039	0.0033	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Trichloroethene (TCE)	<0.001	<0.001	<0.001	0.0016	<0.001	<0.001	<0.001	<0.001	0.0012	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Cyanide (Total)	NM	<0.005	<0.005	0.036	NM	<0.005	<0.005	0.013	0.038	<0.005	10.6	<0.005	<0.005	0.01	0.2
Chemical Oxygen Demand (COD)	NM	<1	<1	<1	NM	<1	<1	<1	<1	<1	54	<1	19	<1	NA

Concentrations are in mg/L, except as indicated.

NM = not measured

(1) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) MCL is for Total Xylenes

**TABLE 3-2. COMPARISON OF DOWNGRAIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR THE JUNE 2008 SAMPLING EVENT**

Parameter	June 2008 Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				MCL ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
Field pH (s.u.)	9/9	6.8	7.54	7.66	<u>8.18</u>	HL-90-3	4/4	7.88	7.89	8.14	NA
Field Specific Conductance (µmhos/cm)	9/9	731	960	929	1356	EPA-1	4/4	1844	1017	4418	NA
Sulfate	9/9	51	142	160	190	MPC-1	4/4	311	92	1000	NA
Chloride	9/9	33	58	55	92	EPA-1	4/4	36	28.5	65	NA
Nitrate+Nitrite as N	7/7	0.73	7.28	8.9	11.8	MPC-1	4/4	6.79	3.78	18.8	10
Arsenic (Dissolved)	0/7	<0.005	<0.005	<0.005	<0.005	N/A	2/4	0.014	0.0065	0.037	0.020
Cobalt (Dissolved)	0/7	<0.01	<0.01	<0.01	<0.01	N/A	1/4	0.013	<0.01	0.02	NA
Copper (Dissolved)	0/7	<0.01	<0.01	<0.01	<0.01	N/A	1/4	0.013	<0.01	0.02	1.3
Iron (Dissolved)	1/7	<0.03	0.030	<0.03	0.03	EPA-1	1/4	0.678	<0.03	2.62	0.3 ⁽²⁾
Nickel (Dissolved)	1/7	<0.01	0.011	<0.01	0.02	EPA-1	1/4	0.020	<0.01	0.05	0.100
Vanadium (Dissolved)	0/7	<0.1	<0.1	<0.1	<0.1	N/A	1/4	0.20	<0.1	0.5	NA
1,1,1-Trichloroethane	0/9	<0.001	<0.001	<0.001	<0.001	N/A	1/4	0.0018	<0.001	0.0042	0.2
1,1-Dichloroethane	4/9	<0.001	<u>0.0013</u>	<0.001	<u>0.0026</u>	HL-99-3	0/4	<0.001	<0.001	<0.001	NA
Chloroform	6/9	<0.001	0.0025	0.0016	<u>0.0095</u>	HL-90-3	1/4	0.0023	<0.001	0.0063	0.06
Cis-1,2-Dichloroethene	2/9	<0.001	<u>0.0011</u>	<0.001	<u>0.002</u>	HL-99-1	0/4	<0.001	<0.001	<0.001	0.07
Dichlorodifluoromethane	1/9	<0.001	<u>0.0011</u>	<0.001	<u>0.0017</u>	HL-99-3	0/4	<0.001	<0.001	<0.001	1.0
Tetrachloroethene (PCE)	6/9	<0.001	<u>0.0031</u>	0.0033	0.0062	MPC-1	0/4	<0.001	<0.001	<0.001	0.005
Trichloroethene (TCE)	2/9	<0.001	<u>0.0011</u>	<0.001	<u>0.0016</u>	MPC-1	0/4	<0.001	<0.001	<0.001	0.005
Cyanide (Total)	3/7	<0.005	0.0153	<0.005	0.038	HL-99-3	1/4	2.65	<0.005	10.6	0.2
Chemical Oxygen Demand (COD)	0/7	<1	<1	<1	<1	N/A	2/4	18.75	10	54	NA

(1) Downgradient wells are: HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1, HL-94-2.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

**TABLE 3-3. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR ALL SAMPLING EVENTS TO DATE**

Parameter	Period of Record Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				MCL ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
Field pH (s.u.)	315/315	6.42	7.35	7.32	<u>8.59</u>	HL-99-3	111/111	7.43	7.41	8.58	NA
Field Specific Conductance (µmhos/cm)	315/315	8.43	1034	970	3040	EPA-1	111/111	1445	1017	4885	NA
Sulfate	215/215	15	138	131	345	EPA-1	106/106	274	96	1980	NA
Chloride	215/215	2	53.9	41	<u>262</u>	EPA-1	105/106	48.6	27	250	NA
Nitrate+Nitrite as N	192/194	<0.05	7.3	7.61	16.9	EPA-1	101/101	11.5	7.07	73	10
Arsenic (Dissolved)	4/215	<0.005	0.005	<0.005	0.028	MPC-2	44/109	0.007	<0.005	0.1	0.020
Cobalt (Dissolved)	1/195	<0.01	0.01	<0.01	0.01	EPA-1	6/104	0.01	<0.01	0.02	NA
Copper (Dissolved)	0/198	<0.01	<0.01	<0.01	<0.01	EPA-1	1/104	0.01	<0.01	0.02	1.3
Iron (Dissolved)	48/215	<0.03	0.083	<0.03	1.69	MPC-1	38/106	0.291	<0.03	3.14	0.3 ⁽²⁾
Nickel (Dissolved)	24/195	<0.01	0.011	<0.01	<u>0.06</u>	EPA-1	17/104	0.011	<0.01	0.05	0.100
Vanadium (Dissolved)	0/195	<0.1	<0.1	<0.1	<0.1	EPA-1	1/104	0.104	<0.1	0.5	NA
1,1,1-Trichloroethane	57/335	<0.001	0.001	<0.001	<u>0.007</u>	HL-90-1	8/113	0.001	<0.001	0.006	0.2
1,1-Dichloroethane	204/335	<0.001	<u>0.002</u>	<0.001	<u>0.007</u>	MPC-1	0/113	<0.001	<0.001	<0.001	NA
Chloroform	239/335	<0.001	0.002	0.002	0.016	EPA-1	92/113	0.005	0.003	0.037	0.06
Cis-1,2-Dichloroethene	85/312	<0.001	<u>0.001</u>	<0.001	<u>0.011</u>	EPA-1	0/108	<0.001	<0.001	<0.001	0.07
Dichlorodifluoromethane	146/335	<0.001	<u>0.002</u>	<0.001	<u>0.016</u>	EPA-1	0/113	<0.001	<0.001	<0.001	1.0
Tetrachloroethene (PCE)	239/335	<0.001	0.007	<u>0.005</u>	0.094	EPA-1	0/113	<0.001	<0.001	<0.001	0.005
Trichloroethene (TCE)	141/335	<0.001	<u>0.001</u>	<0.001	0.007	EPA-1	0/113	<0.001	<0.001	<0.001	0.005
Cyanide (Total)	66/222	<0.005	0.012	<0.005	0.151	MPC-1	23/113	0.950	<0.005	10.9	0.2
Chemical Oxygen Demand (COD)	143/213	<0.3	4.57	4	26	EPA-1	87/107	12.9	8	75	NA

(1) Downgradient wells are: HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: 83-6, HL-06-1, MPC-5, HL-94-1, HL-94-2.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

- (e) PCE was detected in six downgradient wells in the June 2008 sampling event, two of which (MPC-1 and HL-99-3) exceeded the MCL 0.005 mg/L (Table 3-1). The concentration of PCE in well MPC-1 remains consistently above the MCL but is within historical limits. In addition, the potentiometric map (Figure 2-2) indicates groundwater in this area flows toward the extraction system. Well HL-99-3 has shown seasonal fluctuations and a slight decreasing trend in the last six years. Parameter trends are further discussed in Section 3.2.
- (f) Nitrate was detected in all of the June 2008 samples. MPC-2 was not analyzed for nitrate during this sampling event, per the approved sampling event parameter list. HL-90-1 was not analyzed due to low water level in this well which only allowed for a low-volume VOC sample to be taken. Nitrate exceeded the MCL of 10.0 mg/L in one sample collected downgradient of the Helena Landfill (MPC-1) and in one upgradient well (MPC-5). The nitrate concentrations in well MPC-1 have remained relatively constant since 1994 and generally range between 11 mg/L and 13 mg/L, measuring 11.8 in the most recent sampling event. Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 18.8 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse affects became apparent.
- (g) Cyanide was detected in three downgradient wells (MPC-1, HL-99-2, and HL-99-3) and one upgradient well (MPC-5) during the June 2008 sampling event. The downgradient detections were well below the MCL of 0.2 mg/L, but upgradient well MPC-5 (10.6 mg/L) exceeded the MCL. Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through June 2008) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill

(Table 3-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

(h) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). Arsenic was detected in upgradient wells HL-94-2 and MPC-5; cobalt, copper, and vanadium were detected only in upgradient well MPC-5; iron and nickel were detected in downgradient well EPA-1 and upgradient well MPC-5 during June 2008 monitoring (Table 3-1). The detected arsenic and metal concentrations were all at or near their detection limits except for arsenic and iron in upgradient well MPC-5 (0.037 and 2.62 mg/L, respectively) compared to a detection limit of 0.005 and 0.03 mg/L, respectively. Arsenic has historically been at or near this detection limit in well MPC-5; the June 2008 sample is the first to be above the MCL of 0.020 mg/L. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than human health standards). Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through June 2008).

(i) During the June 2008 sampling event, a number of chlorinated organic compounds (i.e., dichlorodifluoromethane, PCE, and TCE) were detected in samples from downgradient wells, but not in samples from background (upgradient) wells (see (a) above). PCE was the only chlorinated organic compound to exceed its MCL in downgradient wells (HL-99-3 and MPC-1). 1,1,1-Trichloroethane was detected only in background well HL-06-1 at a level of 0.0042 mg/L, well below the MCL of 0.2 mg/L. Chloroform was the only parameter detected in samples from both downgradient and background wells. All detections of chloroform were well below the MCL of 0.06 mg/L.

3.2 TEMPORAL CONCENTRATION TRENDS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the June 2008 sampling event, it is also important to evaluate concentration trends of key constituents over time. This report focuses on concentration

trends for PCE and nitrate because they are the only constituents currently exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000. This treatment system involves pumping wells HL-99-1, HL-99-2 and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in the quarterly and semiannual groundwater monitoring events along with compliance well HL-90-1 to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time from 1998 through June 2008 for selected monitoring wells are shown on Figure 3-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells MPC-1 and HL-99-3 for June 2008. Historically, the concentration of PCE in well MPC-1 (now 0.0062 mg/L) has fluctuated between 0.0032 mg/L and 0.017 mg/L based on data collected between May 1992 and June 2008 and showing some increasing and some decreasing trends. The PCE concentrations in pumping wells HL-99-1, HL-99-2 and HL-99-3 have shown seasonal fluctuations and slight decreasing trends since their installation in 1999. Well HL-99-3 fluctuates mostly just above the MCL. Well HL-99-2 fluctuates above and below the MCL seasonally and was below the MCL for the June 2008 sampling. Well HL-99-1 has remained below the MCL for more than four years. Concentrations in downgradient well EPA-1 have decreased significantly since monitoring began (>90 ppb) and have been below the MCL for more than eight years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0078 mg/L after. PCE in this well is currently below the MCL and at its lowest level on record with a concentration of 0.0039 mg/L.

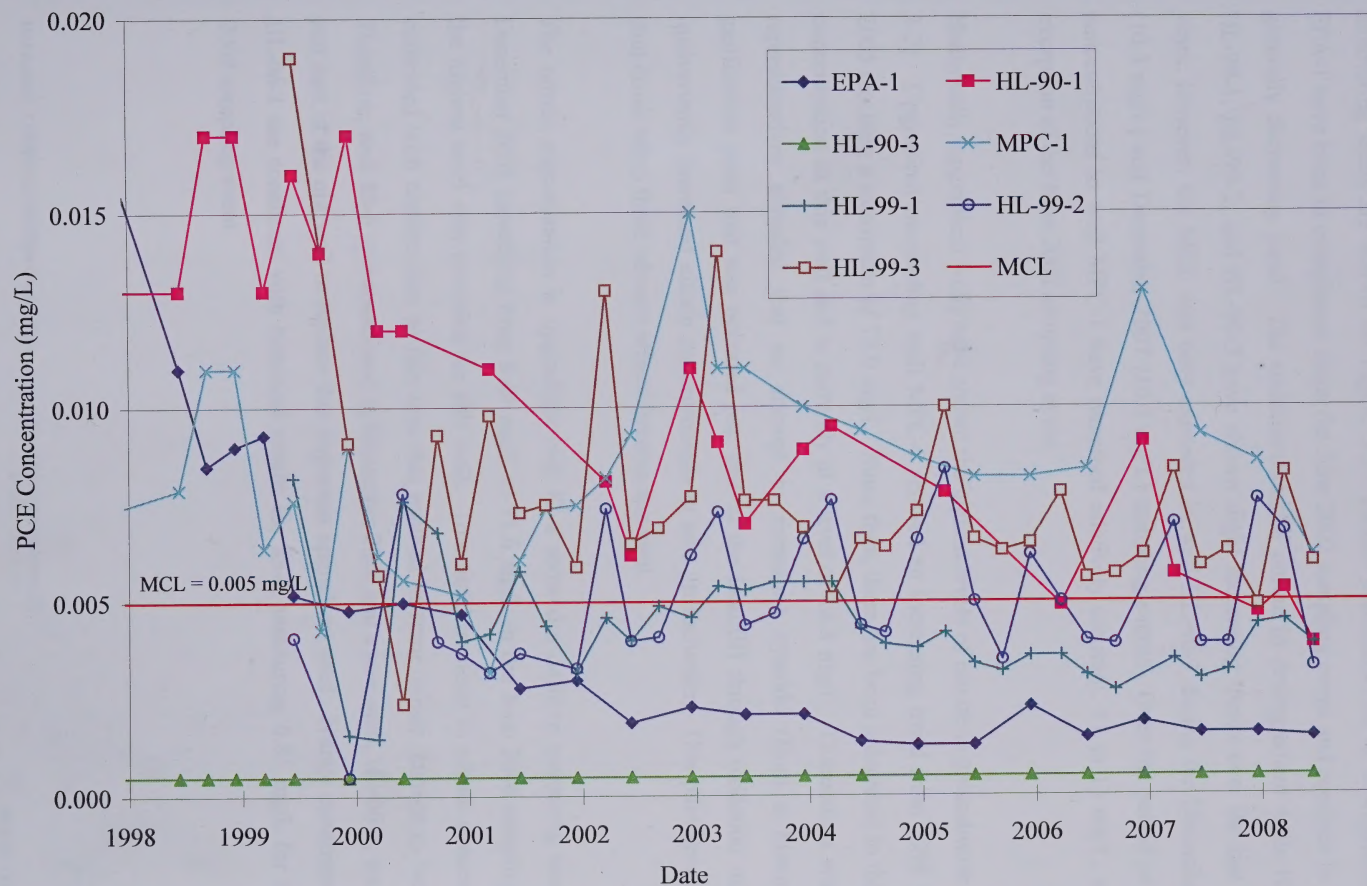


Figure 3-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Downgradient Wells

Trends in nitrate concentrations over time from 1998 through June 2008 for selected monitoring wells are shown on Figure 3-2. Nitrate concentrations at downgradient well EPA-1 have been in compliance since the June 2002 sampling event and continue to show a generally decreasing trend. The concentrations of nitrate in downgradient wells HL-90-3, HL-99-1, HL-99-2, and HL-99-3 have shown slight increasing trends over the last several years; however, the MCL was only exceeded in well HL-90-3 during the December 2006 (10.3 mg/L) and December 2007 (10.3 mg/L) sampling events. Over the period of record, concentrations in well MPC-1 have remained relatively constant, 11 to 13 mg/L, with the exception of the June 2002 sampling event.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 3-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 18.8 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse affects became apparent.

The nitrate concentration in upgradient well 83-6 showed a definite increasing trend since December 2003 increasing from 8.44 mg/L to 71.6 mg/L in the June 2006 sampling event, the highest level ever recorded for this well. This rapid increase in nitrate concentrations coincided with construction in this area that resulted in some minor damage to well 83-6. Therefore, well 83-6 was abandoned in November 2006 and a new well, HL-06-1, was drilled just east of the old well to replace this important upgradient well. Nitrate concentrations in HL-06-1 are consistent with historical results for 83-6, measuring 0.81 mg/L for the June 2008 sampling event.

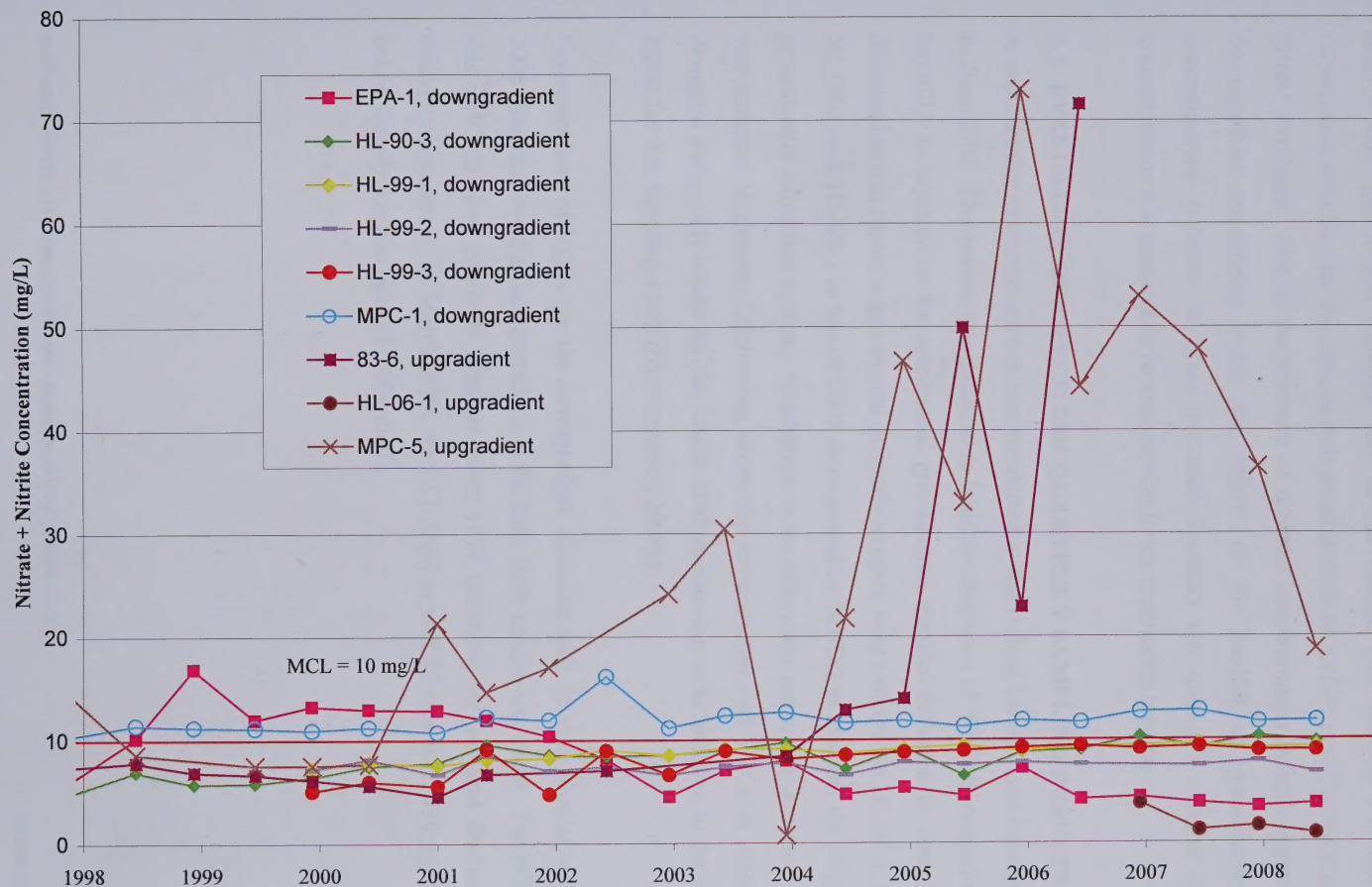


Figure 3-2. Temporal Trends in Nitrate Concentrations at Selected Wells

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill (see Section 3.1) and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

3.3 EVALUATION OF MARCH 2008 QUARTERLY SAMPLING RESULTS

A groundwater extraction system was completed at the Helena Landfill and began operating in June 2000. The system was designed to limit the migration of VOCs downgradient of the landfill. In addition to the semiannual groundwater samples collected in June 2008 and discussed in this report, supplemental quarterly samples were collected at HL-90-1, HL-99-1, HL-99-2, and HL-99-3 in March 2008 as requested by MDEQ to evaluate the effects of the groundwater extraction system. In addition to the extraction wells, one domestic well (#5) was sampled to provide information about the concentrations of VOCs in downgradient domestic wells. All results for the March 2008 monitoring were included in the validation report for that sampling event (Hydrometrics, 2008a).

Concentrations of VOCs for the downgradient domestic well #5 were similar in the March 2008 sampling event to concentrations in the June 2008 monitoring event. The PCE trend in this well has been relatively constant since 1999 (allowing for seasonal fluctuations and analytical precision). In March 2008, the PCE level in well #5 was at 0.0039 mg/L which is below the city's action limit of 0.004 mg/L.

4. CROSS-GRADIENT DATA EVALUATION

Although statistical analyses were not performed using cross-gradient well HL-94-3, a general comparison can be made between the data for HL-94-3 and the data collected for both upgradient and downgradient wells. For the June 2008 sampling event, nitrate, iron, chloroform, and cyanide were the only constituents besides the major anions that were measured at or above their respective detection limits (Table 3-1). The concentration of nitrate exceeded the MCL.

The nitrate concentration at well HL-94-3 of 11.1 mg/L was closer to the average concentration for downgradient wells than upgradient wells reported at 7.28 mg/L and 6.79 mg/L, respectively. The iron concentration in HL-94-3 of 0.07 mg/L exceeded the maximum concentration for downgradient wells reported at 0.03 mg/L, but was within the range of upgradient wells reported at <0.03 to 2.62 mg/L. Chloroform was reported at a concentration of 0.013 mg/L, exceeding the maximum concentration for both upgradient well and downgradient wells reported at 0.0063 mg/L and 0.0095 mg/L respectively. The cyanide concentration in HL-94-3 was reported at 0.010 mg/L, which was closer to the average concentration for downgradient wells than upgradient wells reported at 0.0153 mg/L and 2.65 mg/L, respectively.

5. SUMMARY AND CONCLUSIONS

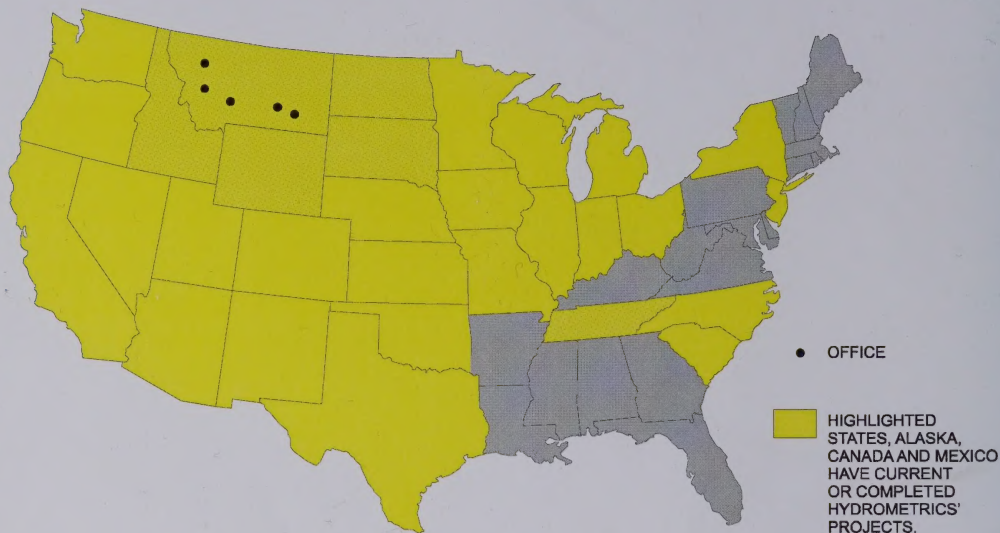
This statistical evaluation of the June 2008 sample results identified two groundwater constituents which exceeded the primary MCL (federal drinking water standard) in one or more downgradient wells: nitrate and PCE.

Nitrate exceeded the MCL in one downgradient well, MPC-1. The range of concentrations observed in upgradient wells (0.81 to 18.8 mg/L) was greater than the range observed in downgradient wells (0.73 to 11.8 mg/L). Historically, concentrations of nitrate in upgradient wells have far exceeded concentrations in downgradient wells. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources such as the historic industrial area east of the landfill and commonly used nitrate fertilizers) are unclear. Monitoring of groundwater nitrate concentrations will continue in future semiannual monitoring events, allowing further evaluation of upgradient and downgradient concentration trends.

PCE exceeded the federal MCL in downgradient wells MPC-1 and HL-99-3. To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2 and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in quarterly and semiannual groundwater monitoring events to evaluate the progress of the new system. Concentrations of PCE in compliance well HL-90-1 have decreased since operation of the groundwater extraction system began and are currently at an all time low of 0.0039 mg/L below the MCL of 0.005 mg/L. Monitoring will continue on a quarterly basis to further evaluate system effectiveness.

6. REFERENCES

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HYDROMETRICS, INC. MONTANA OFFICES

HELENA (Corporate)
3020 Bozeman Avenue
Helena, MT 59601
Phone: (406) 443-4150
FAX: (406) 443-4155

BILLINGS
5602 Hesper Road
Billings, MT 59106
Phone: (406) 656-1172
FAX: (406) 656-8912

MISSOULA
667 East Beckwith
Missoula, MT 59801
Phone: (406) 721-8243
FAX: (406) 542-2619

COLSTRIP
Phone: (406) 656-8305
Fax: (406) 656-8912

KALISPELL
300 Learn Lane
Kalispell, MT 59901
Phone: (406) 471-8635